A PROCESS OF MAKING RARE EARTH DOPED OPTICAL FIBRE

Field of the invention

The present invention relates to a Process of Making Rare Earth Doped Optical Fibre.

Background Art

High silica based optical fibres are firmly established as the most efficient interconnection media for optical telecommunication networks. The fibres are used as the passive transmission media to guide optical signals over long distances. In contrast, rare-earth (RE) ions if doped into the core of such fibres, make them optically active due to the characteristic emission of the RE when pumped at suitable wavelengths. Because of this property RE doped fibres have shown great potential for use as active devices for photonic applications like optical amplifiers and fibre lasers at various wavelengths. The fibres are also found to be promising candidates for their application as sensors for monitoring temperature, radiation dose etc.

Erbium doped fiber which is the active medium of an EDFA (erbium doped fiber amplifier) has been an enabling technology for optical networks operating in the third telecommunication window between 1530 and 1610 nm. EDFA can simultaneously amplify several optical channels in a single fibre which has enabled the implementation of DWDM (dense wavelength division multiplexing) technology with the potential of increasing the bandwidth of long distance transmission systems from Gb/s to Tb/s ranges. EDFAs exhibit high gain, large bandwidth, low noise, polarisation insensitive gain, substantially reduced cross talk problems and low insertion losses at the operating wavelengths. The deployment of EDFA has spurred a tremendous growth in advanced telecommunication systems replacing the conventional optoelectronic repeaters.

While the Erbium Doped Fibre (EDF) remains the most important for telecommunication applications, fibres doped with other rare earths are gaining importance mostly for development of laser sources from visible to mid infrared regions. Development of broadband amplifiers commencing from 1300 nm is an area of great interest using various REs. Lasing and amplification have been demonstrated at several wavelengths with the incorporation of the various rare-earths.

Reference may be made to Townsend J.E., Poole S.B., and Payne D.N., Electronics Letters, Vol. 23 (1987) p-329, ' Solution-doping technique for fabrication of rare-earth-doped optical fibre' wherein the Modified Chemical Vapour Deposition (MCVD) process is used to fabricate the preform with a step index profile and desired core-clad structure while solution doping is adopted for incorporation of the active ion. The steps involed in the process are as follows:

- A conventional cladding doped with P_2O_5 and F is deposited within a high silica glass substrate tube to develop matched clad or depressed clad type structure.
- The core layers of predetermined composition containing index raising dopant like GeO_2 are deposited at a lower temperature to form unsintered porous soot.
- The tube with the deposit is immersed into an aqueous solution of the dopant precursor (typical concentration 0.1 M) up to 1 hour. Any soluble form of the dopant ion is suitable for preparation of the solution although rare earth halides have been mostly used.
- Following immersion, the tube is rinsed with acetone and remounted on lathe.
- The core layer containing the RE is dehydrated and sintered to produce a clear glassy layer. Dehydration is carried out a temperature of 600°C by using chlorine. The level of OH^- is reduced below 1ppm using Cl_2 / O_2 in the ratio of 5:2, provided the drying time exceeds 30 min.
- Collapsing in the usual manner to produce a solid glass rod called preform.
- Fibre drawing is conventional.

Reference may also be made to DiGiovanni D.J., SPIE Vol. 1373 (1990) p-2 "Fabrication of rare-earth-doped optical fibre' wherein the substrate tube with the porous core layer is soaked in an aqueous or alcoholic solution containing a nitrate or chloride of the desired RE ion. The tube is drained, dried and remounted on lathe. The dehydration is carried out by flowing dry chlorine through the tube at about 900°C for an hour. After dehydration, the layer is sintered and the tube is collapsed to be drawn to fibre.

Reference may also be made to Ainslie B.J., Craig S.P., Davey S.T., and Wakefield B., Material Letters, Vol. 6, (1988) p-139, " The fabrication, assessment and optical properties

of high- concentration Nd^{3+} and Er^{3+} doped silica based fibres" wherein optical fibres based on Al_2O_3 - P_2O_5. - SiO_2 host glass doped with high concentrations of Nd^{3+} and Er^{3+} have been fabricated by solution method and quantified. Following the deposition of cladding layers P_2O_5 doped silica soot is deposited at lower temperature. The prepared tubes are soaked in an alcoholic solution of 1M $Al(NO_3)_3$ + various concentrations of $ErCl_3$ and $NdCl_3$ for 1 hour. The tubes are subsequently blown dry and collapsed to make preforms in the usual way. Aluminium (Al) is said to be a key component in producing high RE concentrations in the core centre without clustering effect. It is further disclosed that Al and RE profile lock together in some way which retards the volatility of RE ion. The dip at the core centre is observed both for P and GeO_2 .

Reference may also be made to US Patent No. 5,005,175 (1991) by Desuvire et al., 'Erbium doped fiber amplifier" wherein the fibre for the optical amplifier comprises a single mode fibre doped with erbium in the core having a distribution profile of the RE ion whose radius is less than 1.9 μm while the radius of the mode of the pump signal exceeds 3 μm. The numerical aperture (NA) of the fibres varies from 0.2 to 0.35 and the core is doped with both Al and Ge oxides to increase the efficiency. The fibre with such design is reported to have increased gain and lower threshold compared to the conventional Er doped fibre amplifiers.

Reference may also be made to US Patent No. 5,778,129 (1998) by Shukunami et. al., 'Doped optical fibre having core and clad structure for increasing the amplification band of an optical amplifier using the optical fibre' wherein the porous core layer is deposited after developing the cladding inside a quartz tube by MCVD process and solution doping method is employed to impregnate Er as the active ion into the porous core to be followed by vitrification and collapsing for making the preform. The solution also contain compounds of Al, say chlorides, for co-doping of the core with Al in order to expand the amplification band. The Er and Al doped glass constitutes first region of the core. Surrounding this are the second and third regions of the core. The third region contains Ge to increase the refractive index. The second region has an impurity concentration lower